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VARIATION OF SHIPS' COMPASSES.

By E. T. ROLLS, A.S T.E.

THE number of calamitous wrecks that have taken place on our shores within the last twelve months from unaccountable error in the dead reckoning, as sailors ominously call it—meaning the estimation of position by course steered, distance run, &c., without recourse to astronomical observations—induces me to believe that the terrible snare of an erring compass more frequently lures the mariner to his destruction than is generally supposed. A man endeavours to make a passage he has made hundreds of times before, he steers the same courses, allows for the tides and winds, and feels as confident of his whereabouts as of walking down a well-known road. The weather is thick; all at once, often simultaneously with the cry of the look-out man, there is a disagreeable sliding, grating sensation, immediately intensified into a violent shock, and the ship is fast on a shoal that had been reckoned miles away. Vain efforts are made by reversing engines or trimming sails to get the unfortunate ship off again. But what success can be expected from such means? A moving mass of two or three thousand tons, such as a moderate size ship represents, with very slight impetus, must almost invariably be immoveably wedged, and if she has gone on with a "fair" wind, her chances are hopeless indeed.

It is not then a time for men to ask themselves how they got there; rather, if it may be, to find means to get away. But soon after, there is probably a formal inquiry into the disaster, and, unfortunately, then its cause can only be surmised, for all evidence has disappeared.

As most are aware, iron ships, or ships containing much iron, are swung for compass adjustment before proceeding on their voyage. They are taken to a convenient spot, moved into various positions with regard to the magnetic meridian, and the compasses compared with standards on shore. Naturally the former are more or less affected by the iron surrounding them, possessing, as it always must, a number of magnetic poles indiscriminately arranged, sometimes aiding, sometimes neutralising each other, the result, of course, affecting the compasses proportionately with its magnitude, and deflecting the needles from the proper position, which has to be restored by the introduction of counteracting magnets on the deck.

Now, if all these conditions were immutable, all would be well. But it has been proved, over and over again, that they may easily be disturbed. A blow to the ship in warping out of dock, a heavy sea striking her, a slight collision with another vessel: all these quite likely events in the career of any ship have been actually known to so destroy the equilibrium of magnetic forces as to render the compass the mariner's most deadly enemy, instead of the inseparable and faithful friend it should always be.

Various plans have been suggested as cures for this fearful evil, the *modus operandi* being, as a rule, directed to removing the standard compass beyond the magnetic field of the ship, generally on a tall tripod; but with iron lower masts this can scarcely be successful. Others have suggested the bowsprit end, and reading the card by means of a mirror and telescope. Iron bowsprits are common, and would therefore offer some of the disadvantages of the iron masts: they are frequently damaged, and, further, many steamers have none.

My plan does not aim at removing compass variation; I fear that is impossible, but simply to ascertain at any moment if it exists, and then to correct it. I propose to do this by providing each ship with a pair of astatic needles properly mounted, and having one end of the upper needle shaped as an indicator or pointer; the needles would be used thus:—

At the time of swinging the ship, and after the adjustments had been made, the compass card should be removed from the ship's standard compass, and replaced by the astatic needle, in such a manner that these should move freely upon the same axis that had pivoted the compass card, taking care to introduce the needles with their indicator pointing forward.

The astatic needles, apart from magnetic influence, would of course retain any position given them; but here their position will be determined by the magnetic forces surrounding them, and they will, therefore, as soon as their oscillations have ceased, assume a definite direction. Let this direction be carefully noted by recording it with a mark upon the interior of the compass—a companion, in fact, to the "lubber's point"—and we shall have all that is required, and the compass card can be replaced. After this observations for the constancy of the compass can at any moment be made. It will simply be necessary to introduce the astatic needles as before, and note the position they assume. If it corresponds with that observed at the time of swinging, well and good; if it does not, then the conditions must have altered, and the correcting magnets should be adjusted until the combined needles have their indicator brought opposite the recorded mark, when the compass card may be returned to its place, and its correctness will be found to be restored.

BLOCK SIGNALLING.

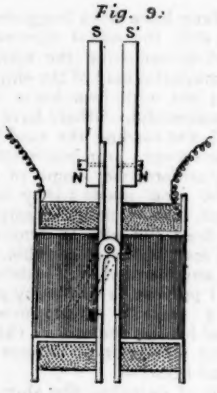
Continued from p. 23.

THE following comprises the forms of instruments now in use:—

Cook and Wheatstone's needle instrument.
Preece's three-wire semaphore system.
Spagnoletti's needle disc.
Walker's semaphore.
Tyers's semaphore.
Preece's single-wire semaphore system.

The first of these—Cook and Wheatstone's—has already been described. In operation it remains the same, but some improvement has been made in it by employing induced instead of permanent magnets. The manner in which this is effected is shown in the accompanying sketch:—

Fig. 9.



Two permanent steel magnets, N S, N' S', are arranged immediately above a soft iron needle *s n*, which is fixed upon the spindle carrying the outer or indicating needle. So long as the soft iron needle *n s* remains within the magnetic field of the permanent magnets it will possess magnetic power the same as that imparted to the permanent magnet which it supplants, and will, of course, be actuated in a similar manner; but not in a similar manner will it be demagnetised or reversed by atmospheric electricity. The passage of an atmospheric current may for the instant reverse the position of the needle, but it cannot go beyond this; there is, therefore, no possibility of a "clear" signal being given for a "blocked" signal. In this respect, therefore, the instrument has undergone a great improvement. There still remains, however, the old objections to it as a talking instrument. Any instrument which it is possible to employ in this manner is objectionable as a *block* instrument. Men shut up for many hours, with, perhaps, but few trains passing, are prone to relieve the monotony of their duty by a passing remark with those at hand, and it is pleasant sometimes to know what is doing at A, whilst B is some miles out in the country. Conversation of this kind leads to forgetfulness, and an error is easier made than repaired. Railway companies would be wise to remove from their men the means of committing an error in all cases where it is possible.

It has been stated that Mr. Spagnoletti's instrument is practically a single needle instrumentt For this reason it may be as well to deal with i, next in order. In outward form, and in operation it remains the same as already shown, but its internal arrangement has undergone considerable improvement. The permanent magnet by which the movement of the shield carrying the indication "train on line" "line clear" is effected, has been replaced by an induced magnet. This Mr. Spagnoletti effects in his own way and in the following manner (fig. 10): *a* and *b* are two parts of a divided needle or magnet of soft iron, fixed together at *e*, but with a piece of brass or non-magnetic material between them, the joint being usually made by brazing or soldering; *a'* and *b'* are the two parts of the axle or spindle carrying the indicating shield.

Fig. 10.

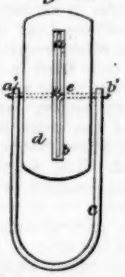


Fig. 11.

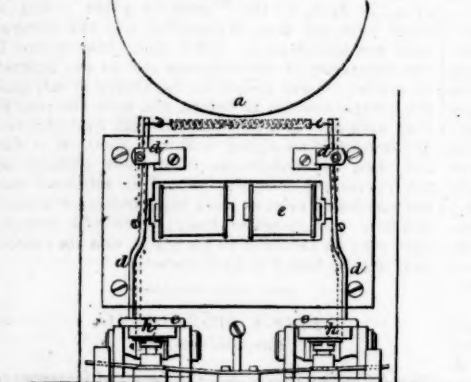
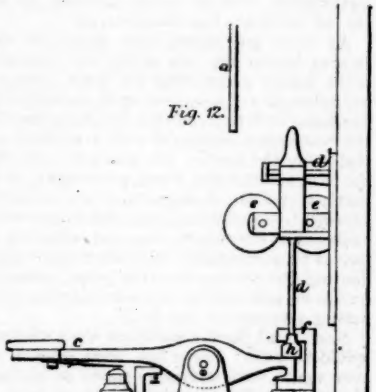


Fig. 12.



It will be observed that these parts are of a piece, with *a* and *b* respectively. C is a permanent magnet, inducing magnetism in the divided soft iron needle or magnet *a b*, through the parts of its axle, *a' b'*, the magnet C being perforated or slotted for the free passage of the axle; *d* are the coils in connection with the line wire, instead of the permanent magnet C; an electro-magnet to perform the same function can be used, in which case a current is transmitted through its coils from a local battery by means of a relay called into action by the line current. With this arrangement the evil effects of atmospheric electricity are obviated; no reversal of magnetism or demagnetization can take place.

The further improvement of this instrument consists in the adoption of a means by which a signal sent by the signalman at one end of the wire may not be negatived and rendered no signal at all by the signalman at the other end of the wire, that is, to prevent both men from holding down the key communicating with the wire at either end of it. When such is the case, each man will be sending a current into the wire, and if these currents are opposed the result will be that no signal whatever will appear on the face of the instrument, but the shield, carrying the signal, will stand midway between the two. In order to render this impossible, or as nearly so as may be, two pairs of electro-magnetic coils are brought into the line circuit. Armatures fixed upon a rod centred above the coils are actuated by the coils on the passage of a current in such a manner as to bring a block of metal attached to the lower end of the rod in the way of the finger key, and prevent it from being worked.

Fig. 11 is a front view and fig. 12 a side view of that portion of the instrument to which the arrangement applies. *a* represents the dial or face of the instrument, *b* and *c* are two finger keys, which on being depressed send—the one a positive, the other a negative—current through its own instrument on to the line wire, and so to the instrument connected therewith at the distant end. The one current produces the "train on line" signal, the other the "line clear" signal; *e e* are the electro-magnets; *d d* levers centred at d^1, carrying armatures opposite the poles of the electro-magnets *e e*, and having at their lower ends blocks *h h*. On the passage of a current through the coils *e e*, these levers become attracted towards them, and the blocks *h h* are carried forward between the ends of the finger keys and the fixed stops *f* placed immediately above them. In the case of the finger key which causes the passage of the current, as it has already been depressed, its block is unable to enter, and is therefore inoperative.

In this way all the finger keys at both ends of the circuit, except that in use, become locked and incapable of being depressed. All possibility of contention or of the neutralization of a signal by the signalmen in communication with each other is then avoided, and although this would appear to be accomplished at some cost in battery power there can be no question but in applying it to his system Mr. Spagnoletti has effected a considerable improvement, and placed his instrument considerably in advance of the ordinary needle-block.

ON A SYSTEM OF TELEGRAPHY.

A Course of Lectures, Delivered at the School of Military Engineering, Chatham. By W. H. PREECE, Member Inst. C.E., &c.

Lecture IV.—A. On the Application of a System of Telegraphy to National Purposes.

(Continued from page 20.)

Every army, whether it be invading an enemy's country or defending its own, must possess a distinct system of telegraphy for military purposes pure and simple. I propose to consider this system under the four following heads:—

1. The permanent line.
2. The semi-permanent line.
3. The flying line.
4. Visual signalling.

1. With regard to the *permanent line*, which I define to be a continuation of the commercial system of the country in which the operations are taking place, or of the establishment of a similar system in the event of there being none or of the original one being totally destroyed, placing Head Quarters in direct communication with its base of operations. I conceive that this system of working into the commercial system of the country must continue to be worked by the civilians who are acquainted with the system of that country. It must remain in sound and good order, and indeed, as well as it can be kept. The arrangements made for its maintenance should be regulated also by the organisation of the commercial system, and the only additional security that would be required would be that it should be guarded in an enemy's country by incessant patrolling.

Supposing, for instance, an enemy landed in force upon the coast of Kent and Sussex, the lines of communication of the army of defence would correspond with the lines of telegraph radiating from London to the coast. These lines would at once be converted into the permanent line. Head Quarters would replace the offices upon the coast. The most perfect and rapid instruments in use in England would be connected up at Head Quarters, which must be maintained in perfect telegraphic communication by many routes with London. On the other hand, suppose that Belgium was occupied by a British Army with a view of protecting it from a French or German invasion, the same process would be adopted, the lines of the country would be utilized, Head Quarters would be converted into a telegraph office. Whatever system be adopted in Belgium, that system should be continued in operation. A system of telegraphy cannot be rapidly exchanged like a suit of clothes, unless, in fact, the whole personnel be changed, which in the case of a friendly power would be a difficult operation.

Supposing, however, a British Army descended upon the coast of some European country, then, unless the advance was excessively rapid, it would probably find all the telegraphs destroyed, the wire recovered, and the poles burnt or broken. In that case it would have to construct a new permanent line of its own, utilizing as far as possible the stores that have been left untaken, and introducing the English Commercial system of working. But, if the advance be so rapid as to

prevent the destruction of the telegraphs, then, as the natives could scarcely be depended upon, or driven to work and maintain them, an army of civilian telegraphists would necessarily or advisedly be employed in maintaining telegraphic communication with home.

A permanent line would also be required between fortress and fortress, and between entrenched camps or strongholds and the country itself. The want of such a system was very much felt in Paris during the recent war, and many efforts were made to establish communication between France and Paris. It is believed that underground wires (deeply laid) and cables laid in the beds of rivers existed, but these were quickly found out by the besiegers and destroyed. It is very doubtful whether it is possible to lay down wires so secretly as to baffle the search of the enemy. Balloons were tried in Paris, but they only succeeded in conveying intelligence in one direction. It would seem that the only practicable system which will enable besieged forces to maintain communication with their friends outside must be a visual and optical system.

It would have been impossible to maintain the siege of Paris, or that of Metz, without such a permanent line as I have defined. Around Paris there were two distinct lines of four wires each, with twenty-four stations upon them, over which thousands of messages were transmitted daily; and the French in the second siege of Paris adopted the same system, connecting Head Quarters at Versailles with Mount Valerien and other points. The heads of trenches and each battery of attack were also connected with Head Quarters and other points of observation regulating the ranges and concentrating the fire upon various points.

2. With regard to the *semi-permanent* line, which I define to be that line which maintains Head Quarters in its advance in communication with the permanent line. In India, during the Mutiny, such a line constructed by using light wires, supported by bamboos, was erected by Colonel Stewart with wonderful rapidity and success, and the Germans maintained such a line in advance into France constructed with slight wires upon slight poles, but rapidly made permanent by a party succeeding the semi-permanent party. In Abyssinia, such a wire was also erected, but owing to the fondness of the natives for the copper of the wire which was used, repeated interruptions were caused by this wire being stolen. It would appear to effect a semi-permanent line with rapidity and good working, that combined light iron and wood poles of that compact and portable form suggested for use in Ashantee, either fitted with screw sockets upon the principle of Mitchell's screw poles, or buried by means of earth borers, would be very useful, but that advantage should be taken as much as possible of trees and other supports to reduce the number of poles used. The wires should be light, and of that kind that practice has shown to be efficient, viz.:—the ordinary three stranded galvanised iron wire is the best. The Americans used a fine steel wire covered with copper, which is said to weigh only 20lbs. per mile of wire, but it is doubtful whether this wire can be coiled and uncoiled with the same ease as the light stranded iron wire I have mentioned. The instruments must of course be of the same kind as those used in the commercial system, for the line itself is only used to maintain Head Quarters, *during its advance*, in communication with the commercial system. The Germans, in their advance upon Paris, were maintained in constant communication with Berlin by means of four Hughes' circuits. The same arrangements for maintenance and manipulation must be adopted for the commercial system.

The civil and military elements in a free country must always meet somewhere; both elements must be employed. A line must, however, be drawn at some point. A telegraph from Head Quarters working into the commercial system of the country, should, as I have pointed out, be worked by civilians. Although the military element may run up the semi-permanent line, it would almost appear advisable that the civilian element should make it permanent and maintain it so to avoid any possible clashing of feelings or interests. Military discipline is essential in the front; it is not so in the rear to the same degree, and there is no reason why the civil element under proper military restrictions should not be employed to maintain communication between Head Quarters and the commercial system.

3. With regard to the *flying line*, which is the military or field telegraph proper to communicate intelligence and orders as quickly as possible to or from the officer in command. It is in fact that telegraph connecting Head Quarters with its divisions. This system, for whatever purpose it may be used, should be based precisely upon the same rules, regulations, and methods, as have already been defined as applicable to a commercial system.

In England your system, as far as its equipment is concerned, is very perfect. It is, however, questionable, how far you are right in maintaining a temporary cable as a conductor. The Germans used generally a thin copper wire erected upon light poles, only using cable* sparingly, and then in the most protected places. The Austrians also use a thin copper wire upon light poles, whilst the Italians in their manœuvres about Verona used light galvanised iron wire, and cable sparingly.

The following paragraph from an American telegraphic paper is interesting as showing what they are doing in America:—

"Military Telegraphs."

"The Military Telegraph system now used in the U. S. Army is probably the most perfect in the world. At the recent examination of Cadets, at the U. S. Military Academy, West Point, N. Y., the operation of the Telegraph Corps attracted great attention. Wires were laid, and the telegraph put in operation at the rate of a mile in ten minutes. The best wire for such purposes is a fine steel wire, covered with copper. This makes a splendid line wire, and only weighs twenty pounds to a mile. A soldier starts off on the run, carrying on his back a couple of reels containing two miles of wire, which he lays along on the ground; he is followed by others, who carry and set the insulating

* The German Cable consists of a strand of 3 copper wires each ·09 inches diameter insulated with 2 layers of gutta percha, and compounded to a diameter of ·6 inches, secured with best Italian hemp, and covered with Siemen's patent flexible copper sheathing to a diameter of ·9 inches.

stakes, attach instruments, batteries, etc. But ordinarily the wire is laid from a waggon carrying the reels from which the wire is unrolled, followed by the insulator waggon, and the instrument and battery waggon. Reels are also provided for use on horseback."

And the following extract is useful as showing what the French are doing:—

"CONDUCTING WIRES FOR MILITARY TELEGRAPHS."

"The conducting wires of the military telegraphs used in the French army are so made as to be capable of resisting the trampling of horses and the crushing of wheels of the heaviest vehicles on common roads, but not that of artillery. Of late, the French military authorities have paid great attention to military telegraphy, and before the war broke out they instituted a series of experiments on it at the Chalons. Lines of wire, says 'Van Nostrand's Magazine,' were laid down in every direction on the public roads, and allowed to remain there day and night for whole weeks at a time, subject to all the passing traffic of horses and vehicles of every description, and to every change of weather; and it was found that, notwithstanding all these trials, messages could be transmitted with perfect accuracy and facility. The wire with which the experiments were tried, and which is used at this moment by the French, is simply a line about one-fifth of an inch in thickness. It is a sort of a miniature submarine cable, and presents the appearance of a thin tarred rope. In the centre of it four threads of copper, twisted together, form the metallic portion which is to conduct the electric fluid, or rather the electric motion. A fine spiral of cotton surrounds them; over this is a thin coating of india-rubber, and the whole, wrapped in a species of vegetable hair, is fastened together and held by two ribbons of impenetrable stuff. The cable is wound round enormous bobbins, ranged in military line, eight and eight, on special vehicles, and is wound off as the army advances. When it is to be used, one of the telegraphers fixes it on the ground by double nails resembling hair pins. But each carriage contains only 1,100 or 1,200 yards of cable, and it frequently happens that the message has to be sent to a greater distance. In this case it becomes necessary to unite the cable already laid with that contained in another carriage."

It is to be observed that the French before the war depended chiefly upon bare wire, but their experience is driving them more to the use of cable.

In India, where the organisation is very perfect, cable has also been used. The cable is very strong, the conductor itself being formed of one copper wire surrounded by six small open wires.

From the consideration of what has been done and the experience we have seen, it seems desirable that a combination between the two is advisable. There are several objections to a cable. In the first place it is heavy, secondly it is liable to fault from the breaking of the wire in rolling and unrolling it rapidly, it deteriorates from constant use, and when faults happen it is difficult to localise them. As far as I could see and learn, the cable which was used in the recent manœuvres was worn out and defective, and, indeed, from the barbarous practice of pricking the wire to localize faults, it is no wonder it has become inefficient.

Overhead wires are preferable but are not always practicable, but a cable courts interruption when it is exposed. A broad distinction must however be drawn between cables in peace and in war. In peace, punishment does not follow the wanton destruction of the wire; in war, such conduct would lead probably to death. It would appear, therefore, advisable to consider the question whether our present system should not be supplemented by light poles and light wire for overhead purposes, instead of depending, as at present, entirely upon the cable. With regard to the instruments which are now used, I am of opinion that considerable improvement can be made. They are of a complicated, expensive form, worked with continuous currents, which only tend to further destroy the cable. I have on several occasions advocated the use of sounders in preference to recorders. The sounder is excessively simple in its construction; it is very rapid in its action, it is highly portable, and has the immense advantage of being more accurate than any other form of instrument manipulated by hand.

I pointed out in speaking of the system of Commercial Telegraphy that the sole object of the organisation there adopted was first to prevent faults, and secondly, when faults occurred, to remove them as rapidly as possible. The arrangement there described for linemen, and inspectors, and testing stations, are as applicable to a flying line of telegraph as to any other, and whether an overhead line or a cable be employed, such testing stations or testing points should be established as to render the necessity for pricking the wire needless. It should be pointed out that in addition to the experienced men employed as linemen, guards should be constantly employed in patrolling the line to see that it is free from disturbance.

4. With regard to *Visual Signalling*, which is that system devised to maintain communication with outposts, pickets, outposts, &c. No distinction should be drawn between a visual and an electric system of signalling in its organization; in fact, the visual system would appear the simpler, as it is free from those wires and posts which are the cause of a majority of those faults which arise in the electric system. With a perfect system of visual signalling it is only necessary to vary the distance between two stations in order to maintain communication during all weathers and seasons. There is a limit to the distance at which telegraphy is of use. The transmission of a message and its transcription take time; hence it is questionable whether any system is useful within a distance of two miles unless the points be separated from each other by obstacles rendering the country inaccessible. In changing front and rapid movements field telegraphy becomes impossible, visual signalling then enters in, and no system could be more applicable. In hilly countries where cavalry cannot act, this system of visual signalling is of the utmost importance. At present, flags of different colours are used, and used simply to suit the different backgrounds. Lines of signallers are sent out in different directions, and they, in point of fact, form separate and independent circuits. They ought to be indicated or numbered, so as to be distinguished from each other, either by a

difference in the shape or colour of the flags used, or in the uniform of the men forming the station, so that there should be no chance of one circuit interfering with another, as occurred on several occasions during the Autumn Manœuvres. Similarly every station should have its call and its code based on the principles which have been detailed as in use in the commercial system. In fact, as I have already pointed out, the whole arrangement of this visual system of signalling should be based entirely upon the principles which are made use of in the commercial system. No distinction should be made in the method adopted of conveying the signals from one point to another. It would appear from a careful inspection of the Army and Navy Signalling Book that some revision is needed in order to render the system in use more uniform with that adopted for railway and commercial purposes. This system of military telegraphy must have a distinct and responsible head, and I conceive that by the constitution of the English army this head must be an officer of the Royal Engineers. It is evident that the Director of Telegraphs must always be kept fully informed of every contemplated movement, of every change, and of the possibility of any change of plan. He must be in a position to anticipate the removal of Head Quarters, otherwise he may be behindhand. He must, therefore, be directly in communication with the general commanding, and it is a question for consideration whether the head of the Intelligence Department and the head of the Telegraph Department should not be one and the same man. The defect in our English departmental system is division of responsibility and routine conduct of business. If A wishes to communicate with D, he must first communicate with B, who must communicate with C, who communicates with D, who replies to C, who transmits this reply to B, who finally communicates it to A. In telegraphic matters routine is obstructive, dilatory, and suicidal.

In all systems of telegraphy two things are essential: the first is *accuracy*, and the second is *dispatch*. Accuracy in the transmission of a message, particularly in military operations, is a matter of vital importance. Accuracy can be ensured in two ways; first by having the message itself repeated by the operator who receives it, secondly by having the message itself repeated by the receiver himself to whom it is addressed. In my first lecture I detailed the method adopted to secure this accuracy in the case of those messages which were sent to vary the meeting places of trains upon a single line of railway. There is no operation in war of more consequence to life and limb than the change of meeting places of trains upon single lines of railway in times of peace. This method is simply that the person who receives the order has to acknowledge the order by sending it back couched in different phraseology. In other words, suppose a general were to send such an order as this:—

"Advance your Fourth Brigade upon Gad's Hill, and there entrench."

If the officer in command who received this message were to reply back:—

"I will advance the 4th Brigade on Gad's Hill and entrench there."

the General who sent the message would have absolute proof that his order had been accurately transmitted and was being acted upon.

The second desideratum is dispatch in the transmission of messages, and this can only be ensured by possessing perfect organization and by maintaining the operators engaged in the transmission of messages in constant practice. Mere schooling of itself is absolutely insufficient. If the schooling be not supplemented by the finishing touch of practice all the value of it is lost. Practice in telegraphy is imperative, operators must be maintained in constant employment, and to be of any value they must possess and retain a slight knowledge of the science upon which telegraphy is based, upon the adjustment of the apparatus they use, upon the connections of the circuits that they adopt, and upon those various technical matters which make up the profession of a telegraph engineer. There is no reason why those who pass through the School at Chatham should not be employed in constant work. The War Department, as well as the Admiralty, have a large and extensive establishment, and the Postal Telegraph Department offers a wide field for the employment of skilled operators. Major Webber has under his control a large district where a number of men can pass through that training which practice and experience alone will give; in fact, it must not be forgotten that the Postal Telegraph system is essentially a department of the Government and it is by useful communication between the War and the Post Office Departments that this large system can be utilized. A large stock of stores is always available as well for war as commercial purposes. For instance, upon a very recent occasion 45 miles of wire were shipped on board the "Himalaya," at Plymouth, at the shortest notice. Telegraph stores—especially apparatus—cannot be maintained in efficient order if they are merely kept in stock out of use. Hence if the Control Department at Woolwich retain large stores of telegraph instruments, as I am told they do, unless those instruments are occasionally used, they will inevitably be found out of order or useless when they are wanted.

The School of Military Engineering at Chatham is unquestionably doing a large amount of good. It is very well equipped, and the officers who pass through the school, if their course of training were only a little longer, might be beneficially and usefully employed. The officers of the Royal Engineers are scattered all over the globe. There are many points in connection with telegraphy and electricity generally, such as atmospheric electricity, which produces such havoc in different parts of the earth; earth currents, which disturb telegraphic currents, and which are but little understood. It is only by the accumulation and correlation of facts gathered from all parts of the earth that we are likely to arrive at any proper knowledge of the cosmical causes of these perturbations. The officers of the Royal Engineers have a grand opportunity to undertake observations of this character, and there is nothing that would tend so much to increase the reputation of the corps as the establishment of a system of scientific inquiry all over the globe.

I am conscious that my lectures have been too general to be of much value. They have been wanting in illustration. The fault has been in the

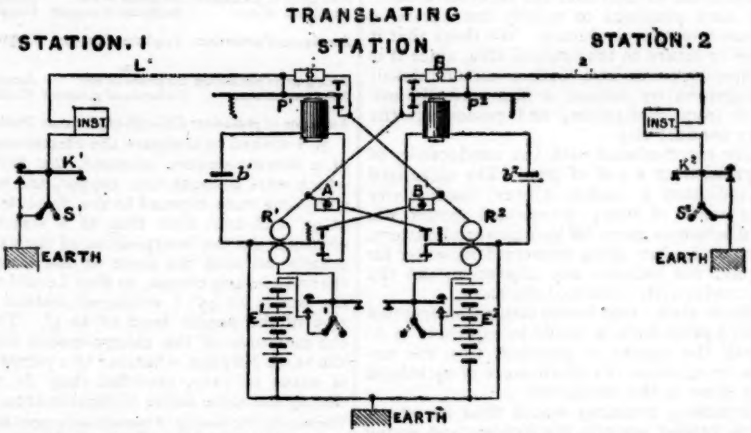
subject. But I trust their effect will not be altogether uninstructive. My object has been to impress upon you the truth that telegraphy is purely a child of experience, and that, under your present constitution, if you ignore the experience of others you will waste very valuable time in acquiring, perhaps too late, experience yourselves.

We give the following in answer to our Queensland correspondent :—

ON A SYSTEM OF WORKING BY TRANSLATION ON A CLOSED CIRCUIT.

By H. R. KEMPE.

This system enables the translation method to be applied to closed circuits without any switches being employed, with the exception of those which may enable the translating station to work independently with the other stations.



In the figure, P_1 and P are the local printers, which are provided with insulated contacts on their lower limiting stop screws.

R_1 and R_2 are relays which call the local batteries b_1 and b_2 into action. They are provided with both top and bottom insulated contacts.

In the normal condition of the circuit, that is when the key switches S_1 and S_2 of stations 1 and 2, and those of the keys at the translating station are closed and the plugs inserted in switches A_1 and B_2, the currents from E_1 and E_2 circulate through the lines L_1 and L_2, the several tongues and levers being in the position shown in the figure.

Suppose now the switch S_1 of station 1 be opened, then the circuit of L_1 being broken, the tongue of relay R_2 falls back to its top contact, and thereby opens the local circuit of printer P_2, whose lever falls back to its limiting stop, and the battery E_2 is cut off from line L_2. The instrument at station 2 is then ready to work.

Now the falling back of the tongue of relay R_2 completes the circuit of relay R_1, which was broken by the movement of the lever of printer P_2, and thereby causes the lever of printer P_1 to remain in the position shown in the figure.

This latter action is necessary, because if the circuit of relay R_1 and battery E_2 were kept interrupted the lever of P_2 would fall back and break the circuit of line L_2 permanently. It is true that the circuit of R_1 would not be instantaneously restored, and the lever of P_2 would give a little jump, but as P_1 is not the recording instrument when station S_1 is working this would be of no consequence.

A resistance may be inserted between the top contact of the relays and the switches A_1 and B_1, which would prevent an excessive drain on the batteries when they act directly on the relays. If it be considered objectionable to use the line batteries for the purpose, local batteries may be inserted in the place of the resistances, the connections from the hinges of the relays being attached to the lower sides of the relays instead of to the wires of the local batteries as shown.

If now we depress key K_1 we complete the circuit of battery B_2, move the tongue of relay R_2, close the circuit of P_2, and thus move its lever, thereby closing the circuit of battery B_2 through the line L_2. This causes the instrument of station 2 to work.

The same reasoning obviously applies when station 2 works to station 1.

When it is required to work from the translating station to stations 1 and 2 independently, the plugs must be removed from switches A_1 and B_1 and inserted in A and B.

This system of translation is clearly applicable to the instruments in common use, and does not require any extra magnets such as are used in the American systems.

We have also received from Mr. Alexander J. S. Adams, Associate of the Society of Telegraph Engineers, a solution of the problem of Translation on a Closed Circuit. It is quite correct; but the arrangement necessitated by it is considerably more complicated than that in Mr. Kempe's method stated above.—Ed.

The Suez-Aden section of the Eastern Telegraph Company's system still remains unrepaired. In addition to the break at Aden, we understand there is one near Suez.

CONSTRUCTION OF LIGHTNING PROTECTORS.

By E. SAINT-EDME.

WHETHER the point of a lightning-conductor is made of platinum or of copper, or whether it is sharp-pointed, as suggested by Franklin, or presents an angle of 30° degrees, in accordance with the latest notions, however great may be the care taken in welding the metals, it is certain that in this respect the mode of construction is defective as regards conductivity, and it is to be feared that the conductivity is diminished by the action of the weather. But it appears further to be demonstrated that it is at the joint that a lightning protector is most often destroyed; it is there the discharge takes place.

At first, Franklin proposed that the conductor should be made of one metal only. It is owing to the rapid oxidization of iron that the successive Commissions have proposed to modify the nature of the extremity of the conductor. We think that it is possible to return to the original idea, since it is known how to cover iron with a metal (nickel) which forms on its surface a film perfectly protecting it from oxidization, and possessing the necessary conductivity.

We have experimented with the conductivity of nickel spread over a rod of iron. The nickelized surface indicated a rather higher conductivity than the mass of iron; it resisted better the electric discharges given off by a powerful battery. This same rod, after being immersed in water for 10 days, did not indicate any alteration, and the electric conductivity remained the same.

We think, then, that in the future construction of lightning protectors, it would be expedient to do away with the copper or platinum tips, the termination being made of a single piece of nickelized iron, the same as the conductor.

The lightning protector would thus become a safeguard against electric discharges, and, owing to the preservation of its point, would always possess the same protective effect.

Again, the conductivity would remain constant, and the necessity of supervision be done away with. This last condition is of great importance, as illustrated by General Morrin. According to him, it is desirable that you should be able to verify automatically the condition of the lightning protector as regards conductivity. In fact, everyone knows that if the conductivity is defective, the lightning protector becomes a source of danger.

THE BAKERIAN LECTURE.

An Account of several new Instruments and Processes for determining the Constants of a Voltaic Circuit.

By CHARLES WHEATSTONE, Esq., F.R.S.,

Professor of Experimental Philosophy in King's College, London, Corresponding Member of the Academy of Sciences at Paris, &c.

Received June 15.—Read June 15, 1843.

(Continued from page 26)

THE following measures were obtained when peroxide of manganese was substituted for the peroxide of lead. The peroxide of manganese was deposited on a platinum plate which formed the positive electrode of a decomposing cell containing a solution of chloride of manganese:—

Amalgam of zinc	Diluted sulphuric acid	Peroxide of manganese 54 turns.
Amalgam of potassium	Diluted sulphuric acid	Peroxide of manganese 84 turns.

A weak current is produced by employing a clean platinum plate in conjunction with the one covered with the peroxide, in which combination the former acts the part of zinc. In this case the positive metal undergoes no chemical action, but on the negative side the peroxide is reduced by the evolved hydrogen.

8. The following measures conclusively show that if three metals be taken in their electro-motive order, the electro-motive force of a voltaic element, formed of the two extreme metals, is equivalent to the sum of the electro-motive forces of the two elements formed of the adjacent metals:—

1.

			Turns.
Amalgam of potassium	Sulphate of zinc	Amalgam of zinc	29
Amalgam of zinc	Sulphate of copper	Copper	30
Amalgam of potassium	Sulphate of copper	Copper	59

2.

Amalgam of potassium	Sulphate of zinc	Amalgam of zinc	29
Amalgam of zinc	Chloride of platinum	Platinum	40
Amalgam of potassium	Chloride of platinum	Platinum	69

9. I wished to compare the electro-motive force of a thermo-electric element, the two metals of which were bismuth and copper, and whose opposite joints were exposed to the fixed temperatures of 32° and 212°, with that of a standard voltaic element. As the interposition of the galvanometer greatly reduced the force of the current in the thermo-electric circuit, so that I could not advance the needle to 45°, I employed instead the reduction of the needle from 10° to 5°. The ratios of the measures of the electro-motive forces remain the same between whatever two points the needle is made to vary, provided they do not change during the same series of experiments.

Thermo-electric element of bismuth and copper, the temperatures of the joints being 32° and 212° 8 turns.
Standard voltaic element of amalgam of zinc, sulphate of copper, and copper 757 turns.

The relative electro-motive forces are therefore as 1 : 94·6.*

Section 12.—The resistance or reduced length of a rheomotor may be ascertained by either of the following processes;—

First Method.—Place the galvanometer and the rheostat in the circuit, and adjust the latter until the needle of the galvanometer stands at a determined point. Then divide the current which passes through the wire of the galvanometer, by placing an equal resistance by its side; the needle will recede. The reduced length, measured by the number of turns of the rheostat, required to be taken out of the circuit in order to make the needle stand at its former point, will be equal to half the total resistance of the undivided portion of the original circuit. The resistance of the galvanometer and connecting wires, and of the coils of the rheostat in the circuit before the experiment, having previously been determined, that of the rheomotor is easily obtained by subtracting the former from the total resistance measured.

* Pouillet, by a very different process, has ascertained this proportion to be as 1 : 95. See "Elémens de Physique Experimentale," 3ième ed. tom. i. p 631.

Let E be the electro-motive force, g the resistance of the galvanometer wire, and R all the other resistances in the circuit. The force of the current acting upon the needle will be—

$$F = \frac{E}{R+g};$$

adding by the side of the galvanometer wire another wire having the same resistance, is equivalent to substituting for it a wire of double section, and the expression for the resistance of the circuit becomes—

$$R + \frac{g}{2};$$

but since, in consequence of the division of the current, only one-half its force acts upon the needle, this action may be represented by—

$$\frac{\frac{1}{2}E}{R+\frac{1}{2}g}.$$

To render this expression equivalent to the first, the resistance R must be reduced one-half, for—

$$\frac{E}{R+g} = \frac{\frac{1}{2}E}{\frac{1}{2}R+\frac{1}{2}g};$$

the resistance taken out of the circuit to effect this reduction is obviously equal to half the resistance of the undivided portion of the original circuit; or—

$$\frac{E}{R+g} = \frac{\frac{1}{2}E}{R+\frac{1}{2}g-\lambda} \qquad \therefore \lambda = \frac{R}{2}.$$

Second Method.—Bring the needle of the galvanometer, by means of the rheostat, to a determined point, which we will call b. Ascertain the resistance r requisite to reduce the needle to a lower point a. Restore it to b; then place a wire to divide the current with the galvanometer, and alter this wire until the needle again stands at a. When the needle stands at b—

$$F = \frac{E}{R+g};$$

when it stands at a in the first case—

$$F' = \frac{E}{R+g+r};$$

in the second case—

$$F' = \frac{E\,r'}{R\,(g+r')+g\,r'}.$$

Equating these two expressions—

$$\frac{E}{R+g+r} = \frac{E\,r'}{R\,(g+r')+g\,r'} \qquad \therefore R = \frac{r\,r'}{g},$$

and as these factors are known, R may be readily determined. The resistance of the rheomotor may be obtained from this as before.

If $r'=g$—that is, if the resistance of the galvanometer wire be equal to that of the wire which diverts a portion of the current from it—then $R=r$.

Third Method.—Bring the needle to any determined point, and ascertain by means of the instrument described at section 18 what degree corresponds to one-half the intensity thus indicated. Since, when the electro-motive force remains the same, the force of the current is simply inversely as the total resistance, to reduce the needle from a to $\frac{a}{2}$ a resistance exactly equal to that previously existing in the circuit must be added; therefore the number of turns of the rheostat required to reduce the needle from a to $\frac{a}{2}$ will be the measure of the total resistance of the circuit when the needle stood at a. The total resistance being thus measured, that of the rheomotor is determined by subtracting from it the known resistances, including that of the galvanometer.

More generally, if the forces of the two currents, a and b, corresponding to two stationary positions of the needle, are known (section 19), the total resistance of the circuit will be—

$$R = \frac{b\,r}{a-b},$$

r being the resistance added to reduce the current from a to b. If $a=2b$, then $R=r$ as before.

Fourth Method.—For this and the following process two exactly equal rheomotors must be employed; their equality may be tested by successively interposing them in the same circuit, when one and the other should deflect the needle of the galvanometer precisely to the same degree.

Place one rheomotor in the circuit and adjust the rheostat until the needle points to any degree arbitrarily fixed upon; then add the second element by the side of the first, and increase the reduced length of the circuit by turning the rheostat until the needle again points to the same division. The known quantity, measured by the number of turns of the rheostat, by which the reduced length of the circuit is increased, is equal to one-half the resistance of a single rheomotor. By placing the second rheomotor by the side of the first, the resistance of that portion of the circuit is reduced one-half; therefore, to restore the former condition of the circuit, a resistance equal to one-half that of the rheomotor must be added. For—

$$\frac{E}{R+r} = \frac{E}{\frac{R}{2}+r+\lambda} \qquad \therefore \lambda = \frac{R}{2},$$

R being the resistance of the rheomotor, and r the other resistances in the first circuit.

Fifth Method.—Place both the rheomotors in series, and vary the resistance until the needle stands at any determined degree. Then place them side by side, and increase the resistance, by turning the rheostat until the needle again stands as before. The resistance of a single rheomotor is equal to twice the resistance required to be added, plus all the resistances in the first circuit except that of the rheomotor—

$$\frac{2E}{2R+r} = \frac{E}{\frac{R}{2}+r+\lambda} \qquad \therefore R = r + 2\lambda,$$

R being the resistance of the rheomotor, r the other resistances in the first circuit, and λ the resistance added by the rheostat to make the force of the current in the second circuit equal to that in the first.

The resistance of one of the elements of the battery described in section 5 I have found to be equal to 2,128 standard units.

Section 13.—The resistance of a standard rheomotor having been accurately determined by either of the processes above described, the resistance of any other rheomotor, in which the electromotive force is the same, may be obtained by a still more expeditious method. The needle of the galvanometer being brought to a determined point when the standard rheomotor is interposed in the circuit: if this be removed, and the rheomotor to be measured be substituted in its place, the number of coils of the rheostat, added to or subtracted from the circuit, to make the current in the latter case equal to that in the former, when added to or subtracted from the resistance of the standard rheomotor, will give that of the rheomotor to be measured. If R' be greater than R, $R' = R + r$; but if R' be less than R, $R' = R - r$. By this simple process the resistances of voltaic elements of different forms, magnitudes, &c., may be readily compared.

(To be Continued.)

Notes.

The *Edinburgh Review* for January contains a fierce and absurd attack upon the Post Office Telegraph Department. The writer has discovered several exquisite mares' nests. He thinks that £500,000 has been improperly accounted for, forgetting altogether the balance held by the Post Office! He asserts that many of those now in the service of the Government, are not only in receipt of higher wages than they received before the transfer, but that they received handsome compensation for the loss of their previous places! He estimates that the 16,000 miles of overladen telegraphs bought by the Government would have been put up for from £27 to £30 per mile—the cost of a single wire line. The article is flavoured too strongly with bias as well as fallacy to merit public attention.

The Direct United States Cable is again interrupted on the American side. This is the third break since the cable was opened for traffic, and strangely each break has occurred within a few days of the re-opening of the cable. Whilst the cable is quietly waiting to be repaired, we do not hear of any further breaks; but, so soon as the repairs are completed, the cable is broken down again. It cannot be icebergs, and vessels do not anchor in that line during this time of year. What can be the cause?

We have received the following as to errors in telegraphic messages to the East: — With reference to errors in messages, if any mistake is pointed out to this company, the error will be traced by message sent on the service of the telegraph, in order to correct any error of that service, and the receiver will be furnished, without charge, with any correction that may be obtained. If the receiver demand a repetition of his message, the inquiry and reply must be paid for under clause 64 of the convention.—The Indo-European Telegraph Company (Limited), 16, Telegraph-street, Moorgate-street, Jan. 14.—*Daily News.*

In our issue of 1st January, we remarked that the *Chiltern* was announced by the chairman of the Eastern Telegraph Company to have left "within fourteen days after the mishap." We are informed by the managing director of the company that she left in four days. It is strange that all the papers giving a report of the meeting agree in stating "fourteen days." The news of the fault was known on the 16th November, and the *Chiltern* sailed from Gravesend on the 20th November.

The traffic receipts of the Great Northern Telegraph for the month of December were 371,445 fr., against 293,409 fr. for the same period last year, the total for the year 1875 being 4,215,315 fr., compared with 4,411,721 fr. for 1874.

The Direct Spanish Telegraph Company (Limited) inform us that telegraphic communication by the Spanish land lines between Santander and Madrid, which has been very irregular and even sometimes entirely interrupted during the last few days, owing to the snow, is now completely restored.

The Berne Postal Congress, which adjourned on the 18th ult., resumed its sittings on the 26th. The Committee of the Congress proposed that the entry of the British Indian Empire and the French colonies into the Postal Union should be agreed to, and that the postage should be fixed at 50c. for letters weighing 15 grammes, this rate to come into force on the 1st of July, 1876. It is also proposed that the question of the entry of other colonies into the Union should be deferred until the meeting of the next Congress. These proposals were agreed to, the ratification of the entry of the colonies being reserved.

The Eastern Extension, Australasia, and China Telegraph Company (Limited) notify that the interim coupon of £2 3s. 10d. on the Six per Cent. Debentures of this company will be payable at the Consolidated Bank, Threadneedle-street, on and after the 1st of February inst.

The Eastern Telegraph Company have just issued their half-yearly report for the six months ended 30th September, 1875, of which the following is an abstract:—"The revenue for this period amounted to £191,410 9s., from which are deducted £6,765 14s. 5d. for rent of special wires, &c., and £48,590 3s. 3d. for the ordinary expenses of the company, leaving a balance of £136,661 8s. 7d. Of this amount, £13,574 11s. 4d. is absorbed by special expenditure during the half-year, as shown in the annexed accounts, and 1,024 os. 2d. by income-tax, leaving the sum of £122,062 17s. 1d. net profit. An interim dividend of 1¾ per cent. for the quarter ended 30th June, 1875, paid on the 14th October last, and a further interim dividend of 1¾ per cent. for the quarter ended 30th September, 1875, paid on the 14th inst., amounting, together with interest on debentures, to £99,077 5s. 6d., leave a balance of £22,985 11s. 7d. to be carried forward. The company's cables are in good working order, with the exception of the Falmouth-Lisbon direct line, which is intended to be repaired in the early part of next summer, and the section of the Indian cable between Suez and Aden. An interruption which recently occurred on this cable is now in course of repair by the company's maintenance ship, the s.s. *Chiltern*, and the directors entertain no doubt that the communication by this line will be shortly re-established. Authority was given to the directors, at an extraordinary meeting held on the 16th day of December, 1875, to increase the capital of the company by the issue of £700,000 in Six per Cent. Preference Shares, for the purpose of duplicating the company's cables from Suez to Aden and Bombay. The particulars of the proposed new issue will be communicated to the shareholders when the necessary arrangements are completed.

A circular has been addressed by Messrs. Siemens Bros. to the shareholders of the Eastern and Eastern Extension Telegraph Companies, enclosing a copy of the correspondence which has passed between them and Sir James Anderson, managing director of the Eastern Telegraph Company, with reference to the partial duplication of their lines. After alluding to the success which has already attended their experience in the construction of telegraph cables, Messrs. Siemens Bros. beg to be allowed to tender for the new cables likely to be required by the company. This offer has, however, been declined. The following extract from a letter addressed by them on the 18th of last December, to Col. Glover, managering director of the Eastern Extention Company, is not without interest:—"As "evidence of the moderation of our prices, we beg "to refer you to our tender of 15th April, 1875, "addressed to your Engineers, Messrs. Clarke, "Forde & Co., in which we offered to manufacture, "ship, transport, and lay a submarine telegraph "cable to connect New Zealand with Australia for "a sum of £248,000. To cover the cost of this "cable your company has raised £320,000, and, "therefore, we may assume that your company is "paying a far higher price for that cable than the "price tendered at by us. Besides, when comparing these prices, it must be borne in mind that "the cable, which, we believe, has actually been "manufactured, is of a cheaper construction than "the cable which has been described in the specification of your Engineers, which was submitted "to us when we were invited to tender."

The Prefect of the Seine has appointed a commission, the duty of which consists in inspecting the lightning rods in connection with the buildings of the municipality of Paris, and reporting upon them. The commission comprises several members of the Academy. Their inspections will be annual, and particular study will be made of certain of the conductors in reference to the storms which pass over Paris.

Proceedings of Societies.

THE CHRISTMAS LECTURES AT THE ROYAL INSTITUTION.

By PROFESSOR TYNDALL

(Continued from page 29.)

III.—Electric Induction.

Professor Tyndall began his third lecture, on Saturday last, with additional experiments showing the double character of the electrical force, the quality being tested in the mode suggested by Du Fay; thus, if any electrified body repel or is repelled by sealing-wax rubbed with flannel its electricity is negative, if it repel or is repelled by glass rubbed by silk its electricity is positive. In this way, with simple electroscopes, he examined the quality of the rubbers, proving that they are electrified as much as the rubbed body, but always opposite in quality. In the case of glass rubbed with silk the electricity of the silk is negative, that of the glass positive; the electricity of flannel rubbing sealing-wax is positive, that of the wax negative. The Professor then adverted to Symmer's theory, which supposes that electric action is produced by two fluids, each self-repulsive but mutually attractive; that these fluids cling to the atoms of matter and carry them along with them; that every body in its natural condition possesses both fluids in equal quantities, mixed together and neutralising each other; and that these fluids are torn asunder by friction, one clinging to the rubber, the other to the body rubber. In connection with this theory, he proceeded to exhibit and elucidate the phenomena of electric induction—that is, the decomposition of the neutral

fluid in a body by the mere presence of an electrified body, without contact, also termed electrification by influence. Thus, when Stephen Gray brought an excited glass tube near one end of a conductor light bodies were attracted at the other end. Dr. Tyndall showed, in a series of experiments, that when a body is electrified by induction one of the fluids is attracted and the other repelled; when the electrified body is withdrawn the separated electricities flow together again, and the neutral condition of the body is restored. If it be touched while in the electrified state, the electricity resembling that of the influencing body passes away, the opposite electricity being retained. In testing the quality of the induced electricity the Professor employed a carrier, consisting of a piece of tinfoil fastened upon a stem of straw and insulated by sealing-wax, by means of which electricity may be conveyed from any body for examination by the electroscope; and he showed that apples and other cheap materials answer quite as well as brass globes and very expensive apparatus. The fact of electric induction was also exhibited by the Professor standing on a stool insulated by glass. When he merely placed his right hand on the electroscope there was no action; but when he stretched forth his left arm, and his assistant alternately brought near him and withdrew a glass tub excited by friction, the suspended gold leaves opened and collapsed in similar alternation. At every approach positive electricity was driven over the gold leaves, and at every withdrawal the equilibrium was restored. The lecture concluded with the explanation of the phenomena of the electrophorus, the invention of Volta. This apparatus was exhibited in the form of a circular piece of tin (the "lid"), with a stick of sealing-wax as a handle in the centre, placed over a resinous surface or a sheet of indiarubber (the "plate"). When the plate was rubbed with flannel or whisked with a fox's brush, it was negatively electrified: and when the lid was placed on it it touched at a few points only, the two being separated by a thin film of air. By induction the excited surface attracted the positive and repelled the negative electricity. When the lid was lifted the two electricities flowed together and neutrality was restored. When the lid was once more placed upon the excited surface and touched by the hand the free negative electricity flowed to the earth, leaving positive behind, and when the lid was lifted it was found to be covered with free positive electricity.

IV.—The Electric Machine.

Professor Tyndall began his fourth lecture on Tuesday last, with an instructive experiment, proving that the electricity of the silk rubber is the reverse of the rubbed glass; and then, after exhibiting the polarity of two balanced magnets, the north pole of one setting to the south pole of the other, he showed that his electrified bodies act in the same manner, the positively electrified being attracted by the negative. Some further observations and experiments having been made with the electrophorus, it was next proved that when an insulated conductor, such as a sphere of metal, is charged, the electricity diffuses itself all over it, but more especially over elongated and pointed conductors; and by means of his carrier and electroscope the Professor showed that the leaves diverged more when the electricity was conveyed from the point of a cone, the corner of a cube, or the edge of a disk, than when it was taken from other parts. Cones made of carrot or turnip were used, as well as more costly apparatus. The electric machine was next described in detail, and its various forms exhibited; one of them, a cylinder machine, made by Mr. Cottrell, at the cost of about 3s. 6d. The first machine, by Otto von Guericke, was a sulphur sphere rubbed by the hand; Hawksbee and Winckler used globes of glass; Bose, of Wittenberg, added the prime conductor; Gordon replaced the sphere by a cylinder; and Planta introduced the plate-machine. Professor Tyndall then explained the action of the machine, in accordance with the principles of induction. When the glass plate is turned, as it passes the rubbers, it is positively electrified. Facing the glass, midway between the two rubbers, is a row of points on which the glass acts by induction, attracting the negative and repelling the positive electricity. The negative then streams from the points against the excited glass, which passes on neutralised to the next rubber, where it is again excited. The prime conductor is thus charged, not by the direct communication to it of positive electricity, but by the deprivation of its negative. The lecture concluded with some remarkable illustrations of the action of points. When a hand is placed over a point, mounted on the prime conductor of a machine in good action, a cool blast is distinctly felt, which is named "the electric wind;" the effect of which was shown in Hamilton's apparatus, termed "the electric mill." Two straws, with points, crossed at right angles, and fastened at their centres by sealing-wax, were made to revolve by the wind streaming from the electrified points. When this phenomenon had been illustrated, the Professor exhibited the experiment whereby Du Fay was led to the discovery of the two electricities. A small piece of silver-leaf was kept floating in the air, being alternately attracted and repelled by an excited glass-tube. In conclusion, by means of strips of paper suspended from the ceiling, Dr. Tyndall showed how a thundercloud may be neutralised by the action of a pointed lightning-conductor. The strips, which diverged by self-repulsion when electrified, suddenly collapsed when a point was brought near them, diverging again when it was removed.

THE SOCIETY OF TELEGRAPH ENGINEERS.

A meeting of this Society was held on Wednesday, the 26th ulto, when a discussion took place on Mr. Fleetwood's paper, "Underground Telegraphs—the London Street Work." The discussion was concluded, and the President announced that, at the meeting on the 9th February, a paper would be read on "Submarine Telegraphy," by Dr. Werner Siemens.

THE METEOROLOGICAL SOCIETY.

The annual general meeting of this society was held on Wednesday evening, the 18th inst., at the

Institution of Civil Engineers, when the anniversary address was delivered by the President, Dr. Mann. In alluding to the establishment of a carefully planned series of observing stations by the society, the President illustrated at some length the absolute necessity of following out the inductive method of research in meteorology, and supported his argument by a reference to the history of all the leading branches of physical investigation. The President compared the meteorological doctrine of high and low pressure areas of the atmosphere, and of the movement of currents of the air under the influence of barometric gradient, to the Newtonian doctrine of gravitation in astronomical physics, to the Daltonian hypothesis of atomic proportions in chemistry, to the dynamic theory of the tides, and to Avogadro's law of the uniformity of the atomic constitution of gases under like conditions of pressure and temperature. He maintained that the perfection and practical application of this law must be worked out by organised and carefully-thought-out plans of observation, such as were now used by the society, and also under circumstances of higher opportunity and greater facility by the meteorological office of the Government. The President incidentally remarked that he believed the recent researches into the vertical circulation of the water of the ocean under the influence of the different specific gravities of its distant parts was virtually tending to the establishment of the same great influence as being the moving spring of the physical dynamics of both the ocean and the atmosphere. In allusion to the recent establishment of the permanent lightning-rod committee by the society, he gave a very interesting account of a visit he had recently made to Professor Melsens, of Brussels, and described the experiments upon which the professor is engaged in investigating the molecular changes brought about in conducting bodies by the passage through them of powerful discharges of high tension electricity. He also gave an elaborate account of the admirable system of defence against lightning which has been adopted at the Hotel de Ville of Brussels. Some curious and notable instances of the molecular effects of lightning discharge were exhibited during the delivery of the latter portion of the address. The report of the Council having been read, the proceedings concluded with the election of Mr. H. S. Eaton, M.A., as President for the ensuing year, and the appointment of the usual officers.

THE TELEGRAPH ELECTRICAL SOCIETY, MELBOURNE.

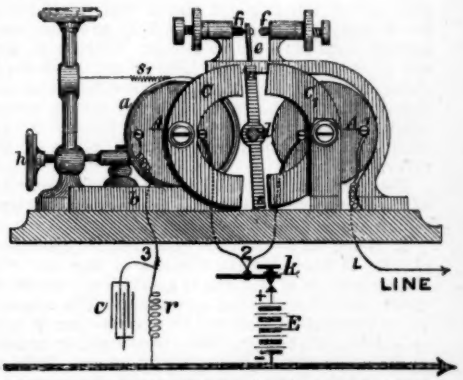
We have been favoured with a copy of the transactions of the Telegraph Electrical Society of Melbourne for the quarter ending 31st July, 1875, along with the report for the year ending the same date. The society has just completed the first year of its existence, and now comprises 49 town members and 79 country members. Their meetings are held in the chief telegraph office at Melbourne, so that ready access may be had, when required, to large battery power and apparatus, which could not be well moved were the meetings held elsewhere. The proposal to make the society a public one, and admit strangers as members, has been negatived, and the rights of membership are restricted to the *employés* of the Postal Telegraph Service. Several valuable papers upon various subjects have been read; and the present number of the transactions includes, amongst others, a valuable note, by Mr. H. J. Aubin, upon automatic translator for closed circuits. Altogether, the society seems to be in as flourishing a condition as can well be expected.

HASKINS'S DUPLEX TELEGRAPH.

(From the *Telegrapher*.)

Since the first patent was taken out in this country for duplex telegraphs by Moses G. Farmer, in 1858, nearly forty other patents, including reissues have up to this time been granted in the United States for inventions of this kind, mostly within the past five years. We have from time to time published in the *Telegrapher* diagrams and descriptions of several different methods of duplex telegraphy, including most if not all of those which have been employed in actual telegraphic service in this country, with the exception of the one which forms the subject of the present article.

The apparatus we are about to describe was invented in the early part of 1874 by Mr. C. H. Haskins, General Superintendent of the lines of the North Western Telegraph Company at Milwaukee, Wis. It is one of the simplest in principle, as well as one of the most effective in operation, of the numerous inventions of the kind now before the public. The novelty of the invention may be said to consist principally in the peculiar manner in which the receiving relay is constructed and operated, and we will, therefore, give a somewhat detailed description of this part of the apparatus before attempting to explain the general principle of operation.



The accompanying illustration is an end view of the relay, the connections and other parts of the apparatus being shown on a small scale and in outline, for convenience of explanation. The relay consists of two spools or helices, A A_1, which are placed parallel to each other, and connected together at the point 2, so as to form a continuous circuit from 1 to 3, precisely in the same manner that the helices of an ordinary relay are arranged. Instead, however, of connecting the two cores

together by means of a yoke piece or back armature, so as to form a single electro-magnet, as is usually done, semicircular pieces of soft iron, C and C, are attached to each end of the core of each helix. Therefore each core, with its pole pieces and helix, in reality constitutes a distinct electro-magnet, having four poles, the two poles at one end having always a magnetic polarity opposite to the two poles at the other end, whenever a current is passing.

Between the two helices A A_1, and parallel to them, is a shaft or axis *d*, carrying at each end a permanently magnetic bar *n s*, which may be termed a polarized armature. In the drawing, *n* represents the north pole and *s* the south pole of one armature, the former being at the top and the latter at the bottom. The position of the armature at the other end of the axis is exactly the reverse of this, the south pole being at the top and the north at the bottom. These armatures are arranged as shown in the figure, their poles being situated directly between the poles C C_1 of the electro-magnets which face each other. A contact arm *e*, rigidly attached to the axis *d*, projects upward at a point midway between the two polarized armatures, and is provided with a contact point. The arm *e* plays between the adjustable stops *f* and f_1, the latter being insulated, and opens and closes the local circuit of the receiving sounder in the same manner as an ordinary relay. An adjustable spiral spring s_1 retains the armature in the position shown in the figure, the local circuit being open when no current is passing. The coil A is mounted in a frame *a*, which slides in a bed plate *b*, and is capable of being moved by means of the screw *h* to or from the other coil and the armature. Thus it will be seen that the adjustments are virtually the same as in the ordinary relay.

The arrangement of the connections is indicated in outline in the figure. The main batteries at each end of the line are placed with their unlike poles towards each other, precisely as in the usual arrangement for a Morse circuit. When both keys are at rest, the main line is to ground at each end through both helices A A_1 of the relays, and also through the resistance *r*. The key merely serves, when depressed, to connect the battery to the main line at a point between the helices of the relay.

There are but three different electrical conditions of the line possible when this apparatus is working, which are as follows:—

I. *When the home key is open and the distant key closed.* If each battery consists of say 100 cells, the resistance of the line is 1,000 ohms, rheostat *r* 1,200, and relay helices 200 each. The strength of current in this case will be $1{,}000 \div (200 + 1{,}000 + 400 + 1{,}200) = 0.35$. This current will go to earth at the home station through both helices of the relays, and the force acting upon the armature *n s* in opposition to the spring s_1 will be $0.35 + 2 = 0.70$ when the distant key is closed, and nothing when it is open.

II. *When the home key is closed and the distant key open.* The current from the home battery divides at the point 2, and to avoid complexity we will assume that the battery has no internal resistance. The strength of the current going to line will be $1{,}000 \div (200 + 1{,}000) + 400 + 1{,}209 = 0.35$; which will therefore act in one coil A_1 of the home relay in opposition to the spring s_1 with a force of 0.35. The other branch of the current going through the rheostat at the home station has a force in A of $1{,}000 \div (200 + 1{,}200) = 0.71$, which is double that of the current going to line, and acts in the same direction with spring s_1. Thus the armature of the home relay is held still with a force of 0.36 whenever a current is sent to line.

III. *When the home and distant keys are both closed.* In this case the line current, in consequence of both batteries being on, becomes $2{,}000 \div (200 + 1{,}000 + 200) = 1.66$, which acts upon the coil A_1 upon the line side, but is opposed by the current in A on the rheostat side in both relays. This, as in the former case, amounts to 0.71. Therefore, the effective force acting upon each armature in opposition to the spring, to give a signal, will be $1.66 - 0.71 = 0.95$.

Thus, in this arrangement we would have, under the conditions stated, an effective force acting upon the armature *n s*, varying from 0.70 to 0.95. It will at once be seen that this great margin enables the operators to work freely over escapes and changes of resistance in the line, which would be impossible in the case of most of the other systems. Thus, in the case cited, in order to disturb the balance of the sender's relay, so as to give him back his own signals, the resistance of the line must be diminished sufficiently to increase the strength of current from 0.35 to 0.71—more than double—which would require a very heavy leakage. In practice, the resistance of the rheostat *r* is made a constant quantity, all necessary adjustments being effected precisely as in an ordinary instrument, and with no more inconvenience.

The condenser *c* may be applied when necessary, in the manner shown in the figure, for the purpose of neutralizing the static discharge. This is effected in this apparatus by causing the condenser to discharge directly into the line wire, so as to destroy the charge coming therefrom, instead of the usual arrangement in a differential duplex, which consists in discharging both the line and the condenser into the earth through the opposing coils of the relay.

This improved duplex was patented by Mr. Haskins in the United States on the 24th of August, 1874. It has been used for two years with great success upon the lines of the North Western Telegraph Company, including some long circuits, like that between Milwaukee and St. Paul. By a recent improvement the apparatus is now operated without the use of a condenser, or analogous device for neutralizing the static discharge, even upon the longest circuits ordinarily worked. Any further information respecting this invention will be cheerfully furnished by Mr. Haskins, who may be addressed at Milwaukee, Wis.

THE NATURE OF THE NEWLY DISCOVERED FORCE.

By GEORGE M. BEARD, M.D.

In my letters to the *Tribune* and in my lecture before the Polytechnic Club, I advanced a theory of the force recently discovered by Mr. Edison, that might perhaps ally it to electricity, though not to any known form, and account for its non-polarity and other phenomena exhibited by it. This

theory I suggested and used merely as a temporary working hypothesis. At the present time, the weight of evidence in my mind is in favour of the theory that this is a radiant force, somewhere between light and heat on the one hand and magnetism and electricity on the other, with some of the features of all these forces. Experiments of the following kind are of themselves powerful arguments in favour of this theory:—

When the wire conducting the force from the battery to the dark box is divided in the air, and the ends are separated even a sixteenth of an inch, no spark appears in the dark box. Lay these ends of the wire on a semi-conductor, as wood, and the force will pass when they are separated a moderate distance. Place small pieces of tinfoil about these ends as they are suspended in the air, and the force now passes one inch or perhaps several inches through the air. Place pieces of tinfoil of larger surface about these ends, and separate them a wider distance, and the force will yet pass. Make the surfaces of tinfoil larger still, until they are a foot square or more, and the force will travel several feet through the air. Prepare three large pieces of tinfoil, place one piece on each end of the divided wire suspended as before, and the other piece about equidistant between them; and still the spark may be seen (though faintly and irregularly) in the dark box. The force must jump from the piece of tinfoil at one end of the wire to the middle piece, which acts as a kind of resting place, and thence to the piece at the other end of the wire. The spark has been obtained (though with difficulty, and only after very nice adjustment of the pencil points in the dark box) after having passed through four pieces of tinfoil, the distance from the first piece to the last being eight feet. The highest tension statical electricity, as generated by Holtz' machine, could not do this; and electricity prefers to pass by points. Through experiments of this kind we have learnt one important law of this force, namely, that it prefers to pass through surfaces; and the larger the surface, the better it passes through any bad conductor, at least within certain limits.

Phenomena of the kind here described suggest magnetism more than induction or dynamical electricity; but this force does not respond to the test of magnetism, the power to attract iron; and, moreover, it exhibits phenomena that do not belong to magnetism. It is attracted by iron and other metals, as conductors, but it does not itself attract iron.

The points which favour the radiant theory of this force may be thus recapitulated:

1. It does not respond to any of the physical tests of electricity, except the spark.
2. It produces no perceptible or demonstrable physiological effects, like electricity.
3. It is not resisted by non-conductors, as air, water, glass, rubber, and paraffin, to the same degree as electricity.
4. It gives no evidence, in any of its phenomena, of polarity.
5. It passes through non-conductors, as air, rubber, glass, &c., most readily by large surfaces at the terminals, while electricity prefers to pass by points.
6. It diminishes in strength with the distance from the battery, possibly in some definite ratio, although that is not yet demonstrated.

Any form of electricity giving a spark like the spark of this force would respond to some of the physical tests of electricity, would produce readily perceptible physiological effects, would be powerfully resisted by the air, and would in all its phenomena suggest polarity, even if rapidly reversed.

Again, the four facts regarded by me as favouring the theory that this force is allied to electricity, are, when severely analysed, not so convincing as they might at first appear. The spark of this force resembles the spark of dynamical electricity; but so also does the spark produced by combustion. The velocity of this force is great, but so also is that of light. This force is best conducted by metals, but so also is heat. This force is resisted somewhat by non-conductors, but so also is heat, and both to a less degree than electricity.

If it be, as I have suggested, a kind of electricity which, after the manner of the shuttle, returns to its source by rapid forward and backward movements, it would yet be electricity under very different conditions from those under which we are wont to consider it, and would be practically a new force. The more I experiment in this department, and the more closely I reflect on the results of experiments, the farther I seem to be driven from the electrical toward the radiant theory of this force; and there would appear to be no ready escape from the conclusion that we have here something radically different from what has before been observed by Science. The relation of this force to the other forces may be thus represented:—

Light, Heat. New Force. Magnetism, Electricity.

The above would represent Mr. Edison's theory of a radiant force, nearer to light and heat than to magnetism or electricity.

The theory I have suggested would bring the force nearer to magnetism and electricity than to light or heat, as follows:—

Light, Heat. New Force. Magnetism, Electricity.

The discovery that broad surfaces at the terminals are necessary to conduct this force through non-conducting solid bodies, as glass, rubber, paraffin, &c., was made but a few nights ago. That the force passed through air when large surfaces were at the terminals had been proved previously by Mr. Edison's experiments and by my own. A large surface of tinfoil (6 by 6 or 12 by 12 inches) was connected with one end of the divided wire, and laid on a table. Over this were placed broad pieces of hard rubber, glass, or paraffin, and on the top of these were placed a similar piece of tinfoil connected with the other end of the divided wire, through which the force was to be conducted to the dark box. In this way it was proved that the force could pass through 2¼ inches of dry wood, two plates of glass, each ¼ inch in thickness, ¼ inch of hard rubber, ¼ inch of solid paraffin, and five layers of paraffin paper. When the surfaces at the ends of the wire were reduced in size, or when the tinfoil at one end was removed, the force passed less easily. When the tinfoil at both ends was removed, and only a few inches of fine wire constituted the surface, the force passed, but through thinner resistance. When only the terminals of the wires were applied to the resisting

body, the force would not pass at all, or but a very short distance. The force passed through eight inches of water, and was apparently but little diminished even when the surface at the terminals was but an inch of fine wire. — *The Scientific American.*

THE ANGLO-AMERICAN TELEGRAPH COMPANY.

THE report of the Anglo-American Telegraph Company to the meeting on the 4th instant states that the total receipts from the 1st of July to the 31st of December, 1875, including a balance of £66,066 brought forward, amounted to £331,313; and the total expenses were £42,841. The directors have set apart the sum of £50,000 to a "renewal fund," leaving a balance of £238,471. One interim dividend, at the rate of 4 per cent. per annum, was paid on the 1st November last, absorbing £70,000, and the directors now recommend a final dividend of 1½ per cent., leaving a balance of £63,471 (including £32,470 surplus cable) to be carried forward. The decrease in the traffic receipts, amounting to £83,405, for the past six months, compared with the corresponding period of 1874, the report further states, "has been caused by competition and the reductions of tariff which came into force on the 1st May, 15th September, and 6th November respectively, the result of which was a falling off as compared with the corresponding periods in 1874, of £643 per day at the 2s. rate, of £1,212 per day at the 1s. rate, and of £485 per day at the 3s. rate." With reference to the latter rate, the report adds that "the earnings under this rate are fairly satisfactory, and therefore it is not proposed by the directors to alter the rate for the present, but to offer such increased facilities as may tend to encourage senders to augment their business, and to make a greater use of the large carrying capacity which this company is enabled to offer." The directors have decided to hold an extraordinary meeting after the ordinary one for the purpose of again submitting the scheme for the division of the stock to the proprietors.

THE NEW POSTAL TELEGRAPH REGULATIONS.

A CONFERENCE of several gentlemen engaged in mercantile pursuits has been held at Gresham-house Old Broad-street, for the purpose of considering the best means of obtaining the withdrawal of the order relative to the use of telegraph stamps. Mr. H. Nicholay occupied the chair. The chairman said the order referring to the use of special stamps for telegraphic messages had taken the mercantile world by surprise, as it was unnecessary, and caused considerable inconvenience. He could see no possible reason for the introduction of such an absurd regulation, except that it had been done for the purpose of throwing obstacles in the way of business men who largely used the wire. He had been informed that the order originated with a subordinate official in the Telegraph Department; but he trusted that the unanimous voice of the mercantile community would show that their business was not to be hampered by unnecessary and useless restrictions. He suggested that a committee should be appointed to draw up a memorial to Lord John Manners, Postmaster-General, protesting against the stamp order. Mr. H. Gibson said the stamp question was not the only grievance business men had to complain of. The department persistently refused to give receipts for messages, so that any one who sent a message to the office by a clerk really had no guarantee that his message had been deposited at the office. The refusal of receipts caused considerable inconvenience, and he mentioned an instance which came under his notice, in which vouchers for a number of telegrams sent to South America were required by auditors. As he had no receipts for money, he had to swear a statement of facts on an affidavit before a commissioner in Chancery. He proposed that the subject should be embodied in the memorial to the Postmaster-General. Several gentlemen addressed the meeting, and a general feeling of opposition to the regulation was expressed. It was stated that the system of payment in ordinary stamps or by cash answered very well. The old telegraph companies issued stamps and stamped message-forms; but they made no charge for them, but allowed a discount of 10 per cent. The Telegraph Department, on the contrary, in addition to the compulsory use of the stamp, actually made a charge of 2d. for twenty shilling-stamped message-forms. A committee, with power to add to its number, was formed to prepare a memorial, and present the same by deputation to Lord John Manners, the Postmaster-General. Mr. W. Felix Robinson, of 33, Poultry, was appointed honorary secretary. Gentlemen willing to co-operate with the committee are requested to communicate with the honorary secretary.

THE following letter refers to the breakage of the Direct Cable:—Sir,—Again our cable is—or in the opinion of most people has been—broken; but I am glad to hear, on inquiry, that the completion of communication with New York *via* Quebec is hourly expected. The *Faraday* returned yesterday, and brought back the broken end of the cable. From the nature of the breakage the directors have no doubt that the cable had been broken both times not only by force but on purpose. Before the opening of the traffic the cable had been lying safely at that place for longer than 14 months, and now, during the short time since the opening, it has been broken twice. Of course, we have no right to suspect any particular party, but it is evident that this ought no longer to be tolerated. The directors have already offered a reward in America for the detection of any one concerned in this rascality; but is it not the duty of the respective governments to give the company all their possible aid in finding out the felons who rob the people of their property? With the shareholders, however, now rests the duty to unite like one man, and demand the laying of a second cable, and providing a repairing ship, which could at the same time watch over our property. Certainly, under these circumstances, we shall find many honest and well-minded people who will help us to raise the necessary capital.—I am, sir, yours respectfully, A Shareholder of the D.U.S.C. Company.—*Daily News.*